Shale gas and fracking: examining the evidence.

As soon as the SGR/ CIEH report was published, some pro-fracking individuals criticised it - mainly via social media and in a letter to the CIEH. Here we summarise our responses to some of the key criticisms.

These additional comments have been collectively compiled by the original authors with additional input from other colleagues within both participating organisations.

Since the central concerns of the report were regulation and climate change, we begin with those issues, and then consider others. At the end, we make a few general points.

Regulatory regime

Concerns about the robustness of the regulatory regime in the UK were a central theme of this report, which we have emphasised. Within our report, we have highlighted numerous concerns and recommendations made by a range of stakeholders, including the Royal Society, the European Commission, and from within the Environment Agency.

Further and direct high level discussions between the CIEH and the Environment Agency following the publication of this report, in particular around the comments in section 2.5, reveal an acknowledgement of the issue of scarce resources. The Environment Agency has advised us that resources are being reprioritised to effectively deal with the regulatory requirements of fracking proposals.

The CIEH has previously voiced specific concerns about the effect of cuts in local government resources are having upon maintaining effective regulation. The tripartite regulatory control mechanisms will have to be suitably coordinated to ensure that regulation is applied appropriately and effectively, which will be a continuing challenge in today's financial climate.

Climate change

Concerns about the role of shale gas in undermining action on climate change were also a central thrust of the report. One critic claimed that, "the IPCC see a clear role for shale gas in addressing climate change". This is not an accurate representation of the evidence presented in their latest report.

The fact that the Fifth Assessment Report (AR5)[1] of the Intergovernmental Panel on Climate Change (IPCC) states that natural gas power technology is a 'bridge technology' does not necessarily imply that shale gas will play any significant role in curbing GHG emissions. Indeed, we note that the median scenarios presented in AR5 for stabilising atmospheric concentrations between 430ppm and 530ppm indicate that total carbon emissions from all natural gas sources would be about 100 GtC (Figure 6.15, Chapter 6). This is about the same size as the carbon locked up in the world's current reserves of conventional gas (Figure 7.2, Chapter 7). Hence, burning any of the reserves of unconventional gas (including shale gas), without Carbon

[1] IPCC (2014). Climate Change 2014: Mitigation of Climate Change. (Working Group III.) http://www.ipcc.ch/report/ar5/

Capture and Storage (CCS) technologies, would likely take emissions beyond that level. And it is important to note that these scenarios also require unabated coal use to virtually halt now. If this does not happen (which is, of course, highly unlikely), the necessary restrictions on natural gas use will be even greater. We note that the uncertainties in these scenarios are significant, but with reserves of unconventional gas being considerably larger than those of conventional gas, the potential for us to far exceed internationally agreed targets through exploiting these reserves is very real.

Critics have also stated, "the IPCC have made it clear that they see natural gas extracted from shale as a key component of greenhouse gas mitigation strategies from now until 2050". This is also not a balanced interpretation of the relevant chapters of AR5. The IPCC presents a wide range of technology and policy options and discusses their implementation in a range of scenarios. Many interpretations of these options and scenarios are possible. Nowhere is shale gas described as a "key component".

It has also been suggested, with reference to the US state of Texas, that shale gas can be complementary with natural gas sources in the electricity supply sector. However, other gas sources are available, such as biogas and synthetic gas (processed from biomass) to which a transition could be made. A report by the National Grid suggested that 5-18% of UK gas could come from biogas by 2020[2]. With much stronger measures on energy conservation in homes, offices and industry, this proportion could be significantly increased.

The central argument of the section, though, is worth repeating: while shale gas may replace coal locally, overall coal (and other fossil fuel) use is increasing. In the absence of a global cap on emissions, the use of shale gas will be as well as, not instead of, coal, thereby resulting in an overall increase in emissions. This is a widely understood conclusion, which was even made by the UK government itself[3]. Proven reserves of fossil fuels are already around five times larger than those which can be burnt and still give us a relatively high chance of keeping below the internationally agreed 2°C global temperature increase. Exploiting new fossil fuel sources is likely to make it much harder to keep below this target, even if technologies like CCS can be rolled out on a large scale. This is the central thrust of the warning by the Committee on Climate Change that we quoted.

Other issues have been raised as follows.

Introduction

We have been criticised for suggesting that the process of extracting shale gas is very different from conventional gas. This is because fluids are unable to flow as freely as they might in more porous rocks such as sandstone. The Advertising Standards Agency upheld a complaint against Cuadrilla for suggesting otherwise, as we highlight in our report. Our point is supported by, among many others, the International Energy Agency in its World Energy Outlook, which states that

[2] National Grid (2009). The potential for Renewable Gas in the UK. http://www.nationalgrid.com

[3] MacKay, D.J.C and Stone, T.J. (2013) Potential greenhouse gas emissions associated with shale gas extraction and use. A report for DECC. Available at: https://www.gov.uk/government/publications/potential-greenhouse-gas-emissions-associated-with-shale-gasproduction-and-use.

unconventional gas sources are "difficult to extract because they are trapped in very tight or low permeability rock that impedes their flow [and thus] the scale of the industrial operation required … is much larger than for conventional production. This means that drilling and production activities can be considerably more invasive, involving a generally larger environmental footprint" [4].

Critics have suggested that conventional gas fields can have well densities comparable to unconventional gas fields. The International Energy Agency states that: "One feature of the greater scale of operations required to extract unconventional gas [compared with conventional gas] is the need for more wells. Whereas onshore conventional fields might require less than one well per ten square kilometres, unconventional fields might need more than one well per square kilometre". It qualifies this statement by saying, "it should be noted that conventional gas fields in mature areas, such as onshore United States or Canada, often have well densities … comparable to those of unconventional gas. However, burgeoning unconventional gas production today tends to replace production that would have come from offshore locations or countries rich in conventional gas, such as Russia or Qatar, in which the well densities are much smaller" [5]. So while there are undoubtedly cases in which conventional gas fields can have well densities comparable to those of unconventional gas fields, it is clear that, as a general rule, this is not the case, and it is misleading to suggest otherwise.

Seismicity

We were criticised for suggesting that "UK geology is substantially more faulted that that of North America". In fact, we use the rather more measured statement that "Britain *tends* [emphasis added] to have more complex and fractured geology [than the US]". Of course there are parts of the US with very complex geology. We go on to be more specific by highlighting that the Fylde, home to the UK's only fracked shale gas well, is known to be faulted, and that the British Geological Survey has warned against fracking in faulted areas.

We fully acknowledge that the UK experiences many (small) earthquakes each year, and that the magnitudes of the Lancashire ones are relatively low (hence our statement that "while fracking activities triggered the earthquakes, they may have occurred naturally at a later date and, given their relatively low magnitude, it is unlikely that similar events would cause significant damage to properties and infrastructure"). However, the fact remains that the two earthquakes in Lancashire were triggered when the UK's only shale gas well to date was fracked, and that these earthquakes damaged the wellbore so severely that the well had to be abandoned. We do not imply that this damage impinged on wellbore integrity in this case. We merely highlight that such incidents, which damage a wellbore to that extent, have the *potential* to result in integrity failure. We acknowledge in the report that data are lacking in this area, with the implication that further work needs to be done to establish whether or not this represents a potential problem.

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[4] p18: http://www.worldenergyoutlook.org/media/weowebsite/2012/goldenrules/weo2012_goldenrulesreport.pdf

[5] p18: Ibid

Water and ground contamination

It has been suggested that we have cherry-picked one study and given no examples of studies which have found no evidence of contamination. We referenced the Jackson study (and others) as examples of ones which found evidence of methane contamination, in order to counter claims by Cuadrilla (and many others within the industry) that no such evidence exists. We make no suggestion, either implicit or explicit, that the studies we referred to are the only ones in the region. We go on to say very clearly that local environmental impacts may be less severe in the UK than in the US, due to more stringent (though still, in our view, inadequate) regulations, and that "the reality is likely to lie somewhere between what proponents claim and opponents fear". We believe this to represent a fair and balanced assessment of the situation, which is largely unknown for the UK.

Water use and waste water

We were criticised for saying that "wells are generally fracked several times over their lifetime". We should have said "wells are sometimes fracked several times over their lifetime". It has been suggested by one commentator that "almost all shale wells are only ever fracked once". We would be interested to see any data on the refrack rate among shale gas wells drilled to date which support this assertion.

That fracking is water-intensive is undisputed. The extent to which this represents a problem, however, is the subject of much discussion, which is a very long way from achieving consensus. It was beyond the scope of our report to carry out a detailed analysis of the evidence on water consumption, and we therefore did not make any claims of our own on this matter. Instead we simply presented the views of Water UK (the water trade body) and the Chartered Institute of Water and Environmental Management (CIWEM). These bodies, respectively, have warned that "Where water is in short supply there may not be enough available from public water supplies or the environment to meet the requirements for hydraulic fracturing" and "Climate change scenarios predict less water availability in the future so whether this level of water use is appropriate in the long term to source energy requires further research".

We would also point out that comparison between life-cycle assessments of water use from different fuel sources, such as between coal and shale gas, can obscure the problems arising from high levels of water use on a specific site.

One commentator has implied that our report raises concerns over the levels of naturally occurring radioactive materials (NORM) in the flowback water. We have raised no such concerns and have made no judgement as to whether or not these levels are acceptable. We simply state that fracking fluid returning to the surface is now classed as radioactive waste (following the introduction of new European legislation in 2011), and is thus likely to require off-site treatment and disposal. Our point is not that the levels of radioactivity are particularly high, but that the high volume of waste water – classified as radioactive and therefore probably (though not definitely) requiring offsite disposal – is likely to place a burden on waste water treatment infrastructure.

There is no dispute about the high number of daily vehicle movements required to transport water and waste water to and from the site – a primary concern for those living close to fracking sites.

Local air quality

The intent of this section, as with other aspects of the briefing, was to provide context and overview. There are three potential sources of air pollution from fracking operations, namely impacts arising from underground activities; on site operations; and vehicular movements to and from the site.

We are confident, despite a statement that we have made "unsubstantiated assertions", that the vast majority of scientists would not disagree with any of these qualified statements for example: "the fracking process within the well itself which may release a range of airborne contaminants" or "local air pollutants from fracking can include volatile organic compounds (VOCs), particulate matter (PM2.5 and PM10) and nitrogen oxides (NOx)."

We are aware of studies elsewhere, most notably the US, including sources cited by some critics which offer evidence suggesting no major issues with the specific pollutants assessed in those studies. However, we are also aware of other work suggesting that "despite a growing body of evidence, a number of data gaps persist". Most importantly, there is a need for more epidemiological studies to assess associations between risk factors, such as air (and water) pollution and health outcomes among populations living in close proximity to shale gas operations."[6] With regards to the Bunch et al study referred to by one critic, this work focused on Volatile Organic Compounds (VOCs). As such the scope of the work, whilst extensive in terms of the measurements made, nonetheless did not cover pollutants of current concern within a UK context and in particular those typically associated with traffic and other uses of internal combustion engines i.e. particulate matter (PM) and NO2. One critic claimed that the Bunch et al study: "did not find levels of air pollution that would cause concern". More accurately this work did not find levels of VOCs that would cause concern. However, as outlined in the preceding paragraph there is other, more recent work, suggesting that further work is needed across a wide range of air pollutants.

For the UK, air pollutants such as PM2.5, PM10 and NOx (particularly NO2) remain a concern. The Commons Environmental Audit Committee is (at the time of writing) conducting an inquiry (following on from its 2011 Report). In February 2014 the EU Commission issued the UK Government with a 'Letter of formal notice' for breaching nitrogen dioxide (NO2) limit values in 16 of 43 zones across the country[7]. NO2 is a pollutant typically closely associated with the use of vehicles and specifically internal combustion engines. Whilst we acknowledge that the problem is particularly acute in urban areas, it is unclear at present how widespread introduction of fracking across the UK would impact on this specific pollutant and indeed others associated with increased vehicular movement.

With regards to the potential for shale gas to reduce overall air pollution within the UK, we accept that future possibility. However to achieve this will be dependent on a wide range of factors. Leaving aside traffic emissions, key amongst these will be a switch away from/phase out coal.

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[6] http://www.researchgate.net/publication/261741800_Environmental_Public_Health_Dimensions_of_Shale_and_Tight_Gas_Development

[7] http://europa.eu/rapid/press-release_IP-14-154_en.htm

Socio-economic issues

Arguments that money is being lost to the UK economy due to current imports of natural gas can equally be made as an argument for accelerated investment and expansion of: energy conservation measures (especially in homes); biogas; electric heating; solar hot water panels; and a wide range of other renewable energy technologies. We discuss this further below.

On the issue of investment being encouraged in both shale gas and renewable industries, we note, for example, the current government's championing of shale gas, while announcing its intention to impose major restrictions on onshore wind farms. We also note its poor treatment in recent years of the solar photovoltaics industry and the domestic energy efficiency industry[8].

Regarding possible negative effects on tourism, we note the lack of academic research on this issue in the UK to date. However, our communication with people in Lancashire (SGR is based in Lancashire) provides some anecdotal evidence that local businesses have serious concerns. We agree that we could have been more specific in explaining our sources in our report. One critic referred to a report on tourism in Pennsylvania as evidence that there is no significant effect. However, we do not think this is relevant evidence, given that there are major social, economic and environmental differences between that state and the UK, and the Pennsylvania report does not explicitly investigate potential effects of fracking.

Can we manage without shale gas?

This is a very broad area, which brings in numerous issues, so our short analysis only sought to scratch the surface.

We realise that we only briefly mentioned energy conservation as a key way of reducing dependence on natural gas sources and, on reflection, we should have been more explicit in describing such measures. Arguably the most important example is in reducing demand for gas for space-heating in the buildings sectors via improved insulation. This can play a very large role but, unfortunately, as we noted above, the current government has a poor record in this area. For example, recent figures from the Department of Energy and Climate Change indicate installations of home insulation have fallen 77-93% following the introduction of the latest government schemes[9].

Another key measure to reduce dependence on natural gas for space-heating is a large-scale switch to efficient electric sources. Heat pumps (especially air-source) have a particular potential here[10]. Indeed, a large increase in the fraction of UK energy supplied through electricity use – especially for heating and transport – is at the heart of numerous low carbon transition studies. This is why we made the main focus of this section the issue of replacing gas in the electricity supply sector. There is widespread agreement for such a shift across government, industry and

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[8] See, for example: Webber P (2014). DECC creates more chaos in the energy efficiency sector. http://www.sgr.org.uk/resources/decc-creates-more-chaos-energy-efficiency-sector

[9] Carrington D (2013). Number of households getting help with insulation plummets. http://www.theguardian.com/environment/2013/dec/30/number-households-insulation-lofts-plummets-green-deal

[10] MacKay, D. (2009) Sustainable Energy – without the hot air.

environmental NGOs. Again, on reflection, we could have made this point more explicitly.

And, as we noted above, concerted efforts to increase the use of biogas are a key part of efforts in this area.

Furthermore, we also note that there are a number of low carbon transition studies that have modelled UK scenarios which do not include use of gas with CCS. For example, WWF modelled two such scenarios in their 2011 study[11] and the Centre for Alternative Technology modelled one in detail in their 2013 study[12].

Further background and wider issues

Our report arose out of a concern that the UK government was championing a new fossil-fuel technology based on narrow economic considerations without adequate attention to environmental and social/ health concerns. Claims were being made by government and industry that seemed to have very limited evidence to support them. A key aim of the report therefore was to critically assess such claims, with reference to the available peer-reviewed literature, as well as wider sources. In addition its publication provided the opportunity to complement and expand the work that the CIEH had done to support the knowledge base of the profession and the CIEH members on the ground who will be called upon to advise the local government planning process.

Some critics have claimed that the report was not impartial because one of its authors was involved in some personal political activity. It is our view that activities within an individual's personal life should not preclude a contribution from that individual to professional work where that individual has experience and/or expertise to contribute. We also note the close links that our critics have with the oil and gas industry.

Impartial analysis on any area of policy-relevant science and technology is difficult to achieve. In an area such as shale gas and fracking in the UK, there are large uncertainties in key areas and significant gaps in the evidence base, so the scope for different interpretations is large. It is unsurprising therefore that academics working on projects associated with the oil and gas industry will have different interpretations of the evidence base to us. This does not and should not preclude professionals (and others) with concerns about new technological developments from having their concerns taken seriously by advocates of these technologies.

We maintain that the report is robust, independent, and is in line with the CIEH's consideration of the precautionary principle to ensure public protection, which is extremely relevant when assessing the impacts of proposed development and SGR's commitment to produce accessible, evidence based information about key concerns relating to new technology, environmental sustainability and society.

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[11] WWF (2011). Positive Energy: how renewable electricity can transform the UK by 2030. http://www.org.uk/renewables

[12] CAT (2013). Zero Carbon Britain: Rethinking the Future. http://zerocarbonbritain.org/